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Journal homepage: www.rangeland.ir



Research and Full Length Article:

Optimum Seed Rate of *Vigna sun-hum* (Tagtaga) for Rangeland Rehabilitation in Sandy Soil of North Kordofan

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Received on: 23/05/2018

Accepted on: 18/08/2018

Abstract. In order to determine the optimum rate of *Vigna sun-hum* seed sowing for rangeland rehabilitation in sandy soil of North Kordofan, Sudan, two trials were conducted separately under managed and unmanaged conditions at El-obeid Agricultural Research Farm in Sheikan locality of North Kordofan State in 2015 and 2016. Seed rates were 1, 2, 3, 4 and 5 Kg/feddan (4200m) and arranged by a Completely Randomized Block Design with three replications. The species in both trials was established under rain-fed conditions by broadcasting seeds on prepared seed beds early in the rainy season. In the managed trial, seeds were broadcasted on a clean seed bed. The first and second weeding was carried out after two and four weeks from seed broadcasting. In the un-managed trial, a bare area or an area with scatter occurrence and low density of herbaceous species was selected annually and weeding was not done. Vegetation cover, density and forage dry weights were obtained using (50x50 cm²) quadrat. MSTAT-C statistical software package was used for the statistical analysis. In both managed and un-managed trials, the results revealed that there were significant ($P \leq 0.001$) differences in most measured variables. In the managed trial of 2015 cropping season, the seed rate of 3 kg/feddan recorded the highest vegetation cover (33.3%) and the highest dry weight (260.3 g/m²) whereas the one kg/feddan had the least vegetation cover (10%) and dry weight (52.1 g/m²). In un-managed trial of 2016 cropping season, the seed rate of 4 kg/feddan recorded the highest density (98 plant/m²) and the highest dry weight (100.3 g/m²) whereas the third seed rate recorded the least density (37 plant/m²) and dry weight (33.6 g/m²). Results of combined analysis indicated that there were significant ($P < 0.001$) differences among the five seed rates in most studied parameters. For *Vigna sun-hum* as endangered leguminous range species, two optimum seed rates of 3 and 4 kg/feddan were recommended for ranches and natural rangeland rehabilitation in the managed and un-managed areas, respectively.

Key words: Seed rate, Density, Vegetation cover, Biomass, Rangeland

Introduction

North kordofan state is one of the most important livestock production areas in Sudan under rangeland conditions. The livestock production systems in the state are nomadic, transhumance and sedentary. The rangeland witnessed a pronounced decrease in natural vegetation in both quality and quantity as a result of overgrazing, human misuse practices, drought and desertification. The livestock in the state is estimated as 25.7 million heads (cattle, sheep, goats and camels) and according to annual feed balance, the feed gap in North Kordofan was estimated as 41% (Ministry of Agriculture and Animal Wealth, 2011). In addition to this, there is an increase in population due to the seasonal movement from south Kordofan state. The high number of livestock caused over utilization leading to range deterioration and palatable plants were replaced by noxious and un-desirable species such as *Xanthium brachycarpum* (Ramtoak), *Abutilon spp.* and *Cassia spp.* Moreover, over grazing in autumn residence in North Kordofan caused deterioration in vegetation and soil and reduced the carrying capacity and the livestock suffer from feed deficiency for long periods. Moreover, animals lost weight and production and death was common due to deficiency of feed. Range and forage plants such as *Cenchrus ciliaris*, *Belipharis sp.*, *Clitoria ternatea* and *Vigna sun-hum* are important sources of feed for animals. The maximum production from a given range unit area is dependent upon proper Management and balanced use of resources (AbdElhag and Babo, 2012). The degradation of the rangeland vegetation in North Kordofan has led to the survival and dominance of short-lived un-preferred annual plant species rather than the palatable perennial ones (ibid). One of the means of rehabilitation, improvement and management of degraded rangeland resources in North Kordofan is reseeding

practice (ibid). Reseeding is seen as a suitable management practice that may increase the production of vegetation from rangeland, leading to improved animal performance and productivity. Yearly range reseeding campaigns undertaken by Range and Pasture Administration of North Kordofan (RPANK) are not effective according to annual vegetation measurement done by the same administration (RPANK) (Dawelbait *et al.*, 2013). Reseeding of most important forage plants is critically needed in North Kordofan because improvement cannot be achieved through natural regeneration or it will take a long time (Mustafa and Elgoni, 2000).

Legumes are important sources of protein for human beings and animals as they nutritionally provide rich crop residue for animal feed and play a key role in maintaining the productivity of soil, particularly through biological nitrogen fixation (ICARDA, 1988). Legumes are more suitable for reseeding than grasses (Bonger, 2009). According to Khatir and Dawelbait (2013) and Dawelbait *et al.* (2013), *Vigna sun-hum*, an endangered leguminous species serves as leguminous important range species in North Kordofan. Field observation indicated that *Vigna sun-hum* was more palatable than *Clitoria ternatea* (as leguminous forage species) and its whole part was consumed by small ruminant (goats and sheep). According to AbdElhag (2018), crude protein, crude fiber and ash contents of *Vigna sun-hum* were 22.6, 20.1 and 10.4%, respectively. Technical package related to optimum seed rate for this important endangered range species under Sudan condition is still lacking. The objective of the current study was to determine optimum seed rate for *Vigna sun-hum* in order to enhance and assure successful range rehabilitation program in dry land of North Kordofan.

Materials and Methods

The study was undertaken at Elobeid Research Station farm (latitudes 11°:20'-16°:36' N and longitudes 27°:13'-32°:24' E) during two rainy seasons (2015 and 2016), north Elobeid city in North Kordofan State. The study area lies within the low-rainfall Savanna sandy soil. Annual rainfall varies between 250-450 mm with the bulk of the highly variable and unpredictable rains, confined to two months of July and August. Rainfall amounts at Elobeid Research Station farm in 2015 and 2016 were 220 and 242mm, respectively. Two current trials were conducted based on previous studies.

Vigna sun-hum (tagtaga) is an annual herb legume selected for determining its optimum seed rate. Purity and germination tests were done before sowing the seeds. Two trials were conducted separately. The first trial was assigned as managed trial whereas the second trial was assigned as unmanaged one. Two sites were selected annually. One site was selected for each trial. According to herbaceous species ground survey, past management and soil samples for seed bank, main criterion for selecting each site was being free from the seeds of *Vigna sun-hum* (tagtaga). For both trials, five applied seed rates were 1,2,3,4 and 5 Kg/feddan. Weeding was done only in managed trial. The species in both trials was established under rain-fed condition. The seeds in both trials were broadcasted in furrow lines and then immediately covered lightly with soil. The depth of each line ranged between 1-3cm. Plot area was 2×2 m² in order to minimize the difference among plots because soil heterogeneity was the prominent feature in Elobied Research Farm. A Completely Randomized Block Design was used with five treatments (five seed rates) and three replications. In managed trial, weeding and preparation of land were done before seed broadcasting and then, the first and

second weeding was done. In unmanaged trial, a bare area or an area with scatter occurrence and low density of herbaceous species was selected annually. Weeding was not done in unmanaged trial and seed broadcasting was done early in the rainy season in order to reduce the competition of other species. According to lazim (2009) and Lazim *at al.*, (2012), vegetation cover, density and forage dry weight (on oven dry weight basis) were obtained at flowering stage using (50 x50 cm²) quadrat. In order to avoid heterogeneity inside each plot (2×2 m²), all forage inside each plot was harvested separately to obtain dry weight. MSTAT-C software program (Freed, 1992) was used for the statistical analyses. Least Significant Difference (LSD) was used for means separation (Steel and Torrie, 1980). We calculated the gross and net benefit depending on how much SDG vr. dollar here in Sudan.

Results and Discussion

Results of vegetation cover, density and dry weight of *Vigna sun-hum* in the managed trial are presented in Table1. Vegetation cover, density and dry weight are the best indicators of range condition and reflect the effect of past management. In the first season (2015), the results revealed that there were very highly significant ($P \leq 0.001$) differences among the five seed rates in vegetation cover, density and dry weight. The seed rate of 3 kg/feddan recorded the highest vegetation cover percent followed by 5kg, 4 kg and 2 kg/feddan whereas the 1 kg/feddan had the least one (Table1).

In the second season (2016), the results indicated highly significant ($P \leq 0.01$) differences among five seed rates in vegetation cover and dry weight; however, no significant differences were observed among first, third and fourth seed rates in vegetation cover. Fourth seed rate recorded the highest vegetation

cover percent followed by the third and one. There was no significant difference ($P > 0.05$) among the five seed rates for plant density. Nonetheless, fifth seed rate had the highest density. For dry weight, the fourth seed rate recorded the highest dry weight followed by third, second and first ones whereas the fifth seed rate had the least one (Table 1). The results in the first season in the managed trial indicated that the third seeds rate had relatively stable performance in term of vegetation cover and dry weight. Studies related to determination of seed rates to range species, especially the palatable and endangered ones under Sudan condition are still limited and lacking. Mustafa and Elgoni (2000) reported that reseedling is usually recommended when range improvement cannot be achieved through natural regeneration or it will take a long time. Costs of land preparation, seed purchase, short viability of some seeds and sensitivity to drought are taken into account (Mustafa and Elgoni, 2000). Range seeding is applicable only in selected localized situations. Sites which have been very badly degraded will not normally recover easily by natural means even when good management and incorporating resting periods are introduced (Bonger, 2009). Also, Mustafa and Elgoni (2000) reported that according to seed sizes, seed rate of purified seeds

first ones whereas the fifth had the least ranging between 1-2 kg/feddans is recommended for range rehabilitation. Seed rate does not depend on purity alone but viability and germination percent could be considered to enhance and assure successful range rehabilitation program in dry land. Seed rate of 2 kg/feddans for *Vigna sun-hum* was used by Dawelbait *et al.* (2013) at Elobied Research Station Farm where the current study was conducted. The frequencies results of *Vigna sun-hum* in the first and second seasons were less than 1 and 2%, respectively (Dawelbait *et al.*, 2013).

Frequency means the occurrence or non-occurrence of plant species and could be used as an indicator for distribution of the species and its dominance. According to Dawelbait *et al.* (2013), using seed rate above 2 kg/feddans for *Vigna sun-hum* probably enhanced the species frequency as well as its productivity. From above mentioned results (Table 1), seed rate of 3 kg/feddans of *Vigna sun-hum* with 100% quality (100% purity and 100% germination) might be suitable for range rehabilitation where land preparation, seedbeds and removal of undesirable species are carried out. However, using seed rate below 3 kg/feddans probably reduces *Vigna sun-hum* productivity.

Table 1. Effect of seed rates on vegetation cover, density and dry weight of *Vigna sun-hum* in managed trial at Elobied Research farm in two rainy seasons (2015 and 2016)

Growing Seasons	Seed rates	Vegetation cover (%)	Density (plant/m ²)	Dry weight (g/m ²)
Season (2015)	1 Kg/feddans	10.0	13.0	52.1
	2 Kg/feddans	15.0	21.6	64.6
	3 Kg/feddans	33.3	40.0	260.3
	4 Kg/feddans	25.0	26.6	175.4
	5 Kg/feddans	30.0	50.0	215.1
	SE±	1.1***	1.8 ***	23.1***
	CV%	7.0	8.8	21.3
Season (2016)	1 Kg/feddans	58.3	41.3	169.5
	2 Kg/feddans	53.3	49.0	232.6
	3 Kg/feddans	63.3	65.0	307.3
	4 Kg/feddans	73.3	58.0	438.7
	5 Kg/feddans	33.3	77.3	143.1
	SE±	5.3 **	11.0 ns	39.4 **
	CV%	16.3	32.7	26.4

** $P \leq 0.01$, *** $P \leq 0.001$. ns: no significant difference.

Results of the effect of five different seed rates on vegetation cover, density and dry weight of *Vigna sun-hum* in unmanaged trial are presented in Table 2. In the first season (2015), the results revealed that there were significant differences among the five seed rates in vegetation cover and plant density ($P \leq 0.01$) and dry weight ($P \leq 0.05$). The fifth seed rate recorded the highest density followed by fourth, third and second ones (Table 2).

In the second season (2016), the results indicated that there was no significant ($P > 0.05$) difference for vegetation cover. However, there was a significant ($P \leq 0.001$) difference for plant density and dry weight. The fourth seed rate recorded the highest density and dry weight followed by fifth, second and first ones (Table 2).

The results in second season in unmanaged trial indicated that the fourth seeds rate had relatively stable

performance in terms of vegetation cover, density and dry weight. Results from Tables 1 and 2 in the managed area versus the unmanaged one support that the intensive management through land preparation, seed beds preparation and removal of undesirable species could relatively reduce the seed rate of *Vigna sun-hum*. From above mentioned results in Table 2, seed rate of 4 kg/feddan of *Vigna sun-hum* with 100% quality (100% purity and 100% germination) accompanied with seed beds preparation might be suitable for range rehabilitation in the bare area or the area with scatter herbaceous species. In the un-managed area, using seed rate below 4 kg/feddan probably reduces *Vigna sun-hum* productivity. On the other hand, using seed rate higher than 4 or 5 kg/feddan probably increases *Vigna sun-hum* productivity but no significantly difference as compared to 4 kg/feddan.

Table 2. Effect of seed rates on vegetation cover, density and dry weight of *Vigna sun-hum* in unmanaged trial at Elobeid Research Farm in two rainy seasons (2015 and 2016)

Season	Seed rates	Vegetation Cover (%)	Density (plant/m ²)	Dry weight (g/m ²)
Season (2015)	1 Kg/feddan	5.0	9.0	28.0
	2 Kg/feddan	13.3	18.6	34.0
	3 Kg/feddan	20.0	30.0	63.0
	4Kg/feddan	30	36.6	105.8
	5 Kg/feddan	28.3	61.6	150.4
	SE±	2.2***	2.0***	18.2 *
Season (2016)	1 Kg/feddan	13.3	42.2	49.0
	2 Kg/feddan	5.0	54.0	33.6
	3 Kg/feddan	6.6	37.0	33.6
	4Kg/feddan	15.0	98.0	100.3
	5 Kg/feddan	10.0	89.0	51.3
	SE±	3.5 ns	6.5 ***	9.6 **
	CV%	27	18.5	13.1

* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$. ns: no significant difference.

Results in Tables 3 and 4 (combined analysis) indicated that there were significant ($P < 0.001$) differences among the five seed rates in most parameters studied. These results might be due to homogeneity in rainfall amount and its distribution between two seasons.

However, rainfall amounts in 2015 and 2016 were 220 and 242mm, respectively. Gaiballa (2011) reported that natural rangelands in Sudan depend essentially on rainfall amount as well as its distribution.

Table 3. Combined analysis for managed trial for two cropping seasons (2015 and 2016) in effect of five different seed rates on three range attributes of *Vigna sun-hum* at Elobeid Research Farm

Seed rates	Vegetation cover (%)	Density (plant/m ²)	Dry weight (g/m ²)
1 Kg/feddan	34.1	27.1	110.8
2 Kg/feddan	34.1	35.3	148.1
3 Kg/feddan	48.3	52.6	283.8
4Kg/feddan	49.1	42.2	307.0
5 Kg/feddan	31.6	60.3	179.0
SE±	4.8*	5.2***	33.4**
CV%	29.8	29.4	41.1

* P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001.

Table 4. Combined analysis for unmanaged trial for two cropping seasons (2015 and 2016) in effect of five different seed rates on three range attributes of *Vigna sun-hum* at Elobeid Research Farm

Seed rates	Vegetation cover (%)	Density (plant/m ²)	Dry weight (g/m ²)
1 Kg/feddan	9.1	25.6	38.5
2 Kg/feddan	9.1	36.3	33.8
3 Kg/feddan	13.3	33.5	48.4
4Kg/feddan	22.5	67.3	103.0
5 Kg/feddan	19.1	75.5	100.8
SE±	3**	5.8***	12.1***
CV%	40.5	27.4	45.8

** P ≤ 0.01, *** P ≤ 0.001.

Table 5 shows that net benefit of seeds rate (3 kg/feddan) of *Vigna sun-hum* had recorded the highest net benefit (3600 SDG/ha) followed by seeds rate (4kg/feddan) of *Vigna sun-hum* (2837 SDG/ha) among other seed rates of *Vigna sun-hum* in the managed trial (Table 5).

Table 6 shows that net benefit of seed rates (4kg/feddan) of *Vigna sun-hum* recorded the highest net benefit (12366 SDG/ha) followed by seeds rate (5 kg/feddan) of *Vigna sun-hum* (12078 SDG/ha) among other seed rates of *Vigna sun-hum* in the un-managed trial (Table 6).

Table 5. Mean yield, Gross benefit and Net benefit (SDG) per hectare of effect of five seeds rates of *Vigna sun-hum* in managed trial at Elobeid Research farm in two seasons of 2015 and 2016

Tested seed rate	Yield kg/ha	Gross benefit SDG/ha	Variable cost SDG/ha	Net benefit SDG/ha	Ranking
1 Kg/feddan	1108	4432	4370	62	3
2 Kg/feddan	1486	5944	6061	-117	4
3 Kg/feddan	2838	11352	7752	3600	1
4Kg/feddan	3070	12280	9443	2837	2
5 Kg/feddan	1791	7164	11134	-3970	5

Table 6. Mean yield, Gross benefit and Net benefit (SDG) per hectare of effect of five seeds rates of *Vigna sun-hum* in un-managed trial at Elobeid Research farm in two seasons of 2015 and 2016.

Tested seed rate	Yield kg/ha	Gross benefit SDG/ha	Variable cost SDG/ha	Net benefit SDG/ha	Ranking
1 Kg/feddan	385	1540	6160	-4620	4
2 Kg/feddan	338	1352	5408	-4056	3
3 Kg/feddan	483	1932	7728	-5796	5
4Kg/feddan	1030.5	4122	16488	12366	1
5 Kg/feddan	1006.5	4026	16104	12078	2

^SDG means Sudan pound (local currency in Sudan)

Conclusion

Growth parameters of a highly palatable endangered leguminous range species as *Vigna sun-hum* were found to be affected by the seed rates as well as management practices. In the managed area where land preparation, seed beds preparation and removal of undesirable species were conducted, seed rate of 3 kg/feddan recorded the highest values in the most growth parameters measured and was economically profitable as compared to other seed rates. In the unmanaged trial where seed beds preparation was conducted alone, seed rate of 4 kg/feddan recorded the highest values in the most growth parameters measured and was economically profitable as compared to other seed rates.

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میزان بهینه بذر گیاه *Vigna sun-hum* مورد نیاز برای احیای مراتع در خاک‌های شنی شمال کشور سودان

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تاریخ دریافت: ۱۳۹۷/۰۳/۰۲

تاریخ پذیرش: ۱۳۹۷/۰۵/۲۷

چکیده. جهت میزان بهینه بذرکاری گونه گیاهی *Vigna sun-hum* برای احیاء مراتع با خاک شنی در شمال کوردفان کشور سودان، دو تیمار آزمایشی بطور جداگانه با وضعیت های تحت مدیریت و عدم مدیریت در مزرعه تحقیقات کشاورزی العبید در شیکان واقع در ایالت شمال کوردفان طی سالهای ۲۰۱۵ و ۲۰۱۶ انتخاب شدند. میزان بذر ۱، ۲، ۳، ۴ و ۵ کیلوگرم در واحد سطح منطقه (۴۲۰۰ متر مربع) در آزمایش بلوکهای کامل تصادفی (CRBD) و با سه تکرار کشت شدند. بذرهایی گونه مورد نظر در هر دو شرایط آزمایشی و تحت آبیاری دیم در اوایل فصل بارش در محلهای مورد نظر پراکنده شدند. در تیمار مدیریت شده بذرها در یک بستر مشخص و پاک پراکنده شدند. اولین و دومین کندن علفهای هرز مزرعه بعد از دو الی چهار هفته پس از بذر پاشی بود. در تیمار غیر مدیریت شده یک ناحیه باز و لخت یا با پراکنده گی تراکم کم از گونه های علف کش بصورت سالانه بدون کندن علف هرز انتخاب شد. پوشش گیاهی و ترام و وزن علوفه خشک در پلاتها (۵۰×۵۰ سانتیمتر مربع) مشخص شدند. با استفاده از بسته نرم افزار آماری MSTAT-C آزمونهای مناسب و لازم انجام شد. نتایج آزمون مقایسه میانگین در هر دو تیمار نشان داد که اختلاف معنی داری در سطح یک درصد در تمامی متغیرها از قبیل پوشش گیاهی، تراکم و علوفه خشک وجود دارد. در تیمار مدیریت شده در فصل کشت غلات سال ۲۰۱۵، میزان بذر ۳ کیلوگرم در واحد سطح منطقه ثبت شد که بیشترین پوشش گیاهی به میزان ۳۳/۳ درصد و بیشترین وزن خشک ۲۶۰/۳ گرم در متر مربع ثبت شد. به همین ترتیب کمترین پوشش ۱۰ درصد و وزن خشک علوفه ۵۲/۱ گرم در متر مربع معلوم گشت. در تیمار غیر مدیریت شده در فصل کشت غلات سال ۲۰۱۶، میزان بذر ۴ کیلوگرم در واحد سطح منطقه ثبت شد که بیشترین تراکم ۹۸ گیاه در متر مربع و بیشترین وزن خشک ۱۰۰/۳ گرم در متر مربع بود. در حالی که سومین میزان بذر با تراکم آخرین یعنی ۳۷ گیاه در متر مربع و وزن خشک ۳۳/۶ گرم در متر مربع ثبت شد. نتایج آنالیز ترکیب شده مشخص نمود که اختلاف معنی داری در سطح یک درصد در میان پنج مقدار بذر مصرفی و پارامترهای مطالعه شده وجود دارد. برای گونه *Vigna sun-hum* که یکی از گونه های در معرض خطر است، دو میزان بهینه بذر یعنی ۳ و ۴ کیلوگرم در واحد سطح منطقه به ترتیب برای تیمارهای مدیریت شده و نشده جهت احیاء و اصلاح مراتع طبیعی و دست کاشت مشخص گردید.

کلمات کلیدی: نرخ بذر، تراکم، پوشش گیاهی، زیست توده، مراتع